# Part X
# TESTING THE OPTICAL PICK-UP OF MP3 VCD/DVD PLAYERS

**Identifying front-end problems in CD players, CDROM drives, laser-disk players and other optical drives is often thought to be a difficult task. This part of the article describes techniques to check functioning of the laser diode, focus voice coil actuator, tracking voice coil actuator and photodiode array**

GP CAPT. K.C. BHASIN (RETD)

If the player is able to read the disk directory, even erratically, the tests described here are unnecessary (unless you suspect an intermittent behaviour of one of the sub-systems) as all major parts of the laser pickup assembly must be functioning properly in order to do this. However, there may be some marginally performing components such as a weak laser diode or shorted turns in the focus or tracking coil.

Sometimes a dirty lens results in symptoms that may be mistaken for much more serious problems.

For intermittent faults, first carefully inspect the pickup assembly for bad solder connections and hairline cracks in the flexible printed cables. Interlock switches may be dirty or wornout. Mechanical problems may result in intermittent behaviour as well.

## When and why to test the pickup

If you have examined the RF test-point with a scope and found a proper eye pattern, this indicates proper functioning of all the major components of the optical pickup. If, however, any of the following are observed, testing of the laser diode, focus and tracking actuators and/or photodiode array is suggested:

1. The start-up sequence does not complete due to obvious failure of the pickup to perform some action. For example, there is no attempt to focus.

2. Focus appears to be established but the directory is never displayed even though the disk spins at the correct speed—or overspeeds or does not spin in the correct direction (clockwise, as viewed from the label side).

3. The eye pattern is weak, distorted or missing at the RF test-point.

Try to eliminate alternative causes before undertaking these tests as there is a chance of damage due to accidents or electrostatic discharge. There is a good chance that the tests will only confirm that the pickup is dead—not many of the faults you will be able to locate are easy to fix.

The following descriptions assume that the pickup is still installed in the player but selected portions are disconnected when required. This enables you to conveniently use the circuitry of the player to control certain functions for the 'live' laser diode and photodiode tests.

It is also possible to test the pick-up in standalone condition, but this requires an alternative power supply to drive the laser diode. Since the microcontroller will not be imposing its own will on those parts of the pickup still connected to the

*Fisher Electronics Slim-4000 vertical 4-CD stereo system with digital AM/FM stereo tuner & tower speakers*

player, this may be preferable. Caution: Whenever applying external power to any component, totally disconnect it by unplugging or unsoldering (label each wire if there is any ambiguity) to prevent damage to the circuitry on the logic board.

## Tools, documents and test equipment

Only a minimum of tools and test equipment are required for these testing techniques to be effective. An oscilloscope is desirable. However, a digital multimeter can work as a substitute as no high-frequency measurements are needed. We assume here that a scope is available. It is also assumed that the sled drive, or the drawer or spindle motors, are functional, as their correct operation may be required for some of the tests.

A schematic will help greatly. Depending on the design of the unit, you'll be able to infer enough about the front-end electronics to get away without one. The design of the components of the optical pickup is usually similar among CD players from different manufacturers, which makes the tests relatively model-independent. What may differ are polarities of photodiodes, laser diodes, connector pinouts, etc. These can usually be determined quite easily.

Despite the incredible precision of the focus and tracking servos, you can perform meaningful tests without sophisticated or specialised test equipment.

The following tools and test equipment are required:

1. Basic hand tools including jeweler's precision screwdrivers

2. Digital multimeter

3. Oscilloscope (for photodiode/RF tests). For most of the tests, almost any scope will do as long as it has a DC-coupled vertical amp.

4. A 0-5V variable DC power supply (500 mA). You can use a fixed 5V supply with a series adjustable resistor (100 ohms for focus and tracking actuator testing, and 250 ohms for laser diode testing). A highly regulated supply is not needed

5. Resistors: 22 ohms (1W), 5 ohms (1W), 50 ohms and 1 mega-ohm

6. Assorted test clip leads and a few centimetres of 25SWG solid hookup wire

7. IR detector circuit, infrared (IR) detector card or IR sensitive camcorder (for laser diode tests)

8. Low-speed (1-10Hz) sweep or function generator with low-impedance output or amplifier

## Precautions

To minimise the chances of damage to the laser diode, which is extremely sensitive to static and excess current, leave its connector plugged into the main board and do not attempt to test the laser diode with an analogue multimeter (which on the low-ohms scale may exceed the current rating of the laser diode).

As with all modern solidstate equipment, preventing electrostatic discharges to sensitive components is critical. An antistatic wrist strap is desirable. In any case, work in an area where static charge build-up is minimised—not on a carpet prone to static build-up. Touch the metal chassis first to discharge yourself.

## Basics of an optical pickup

For information or music to be read off a CD, several systems must work closely together:

1. Laser must be emitting a coherent beam of sufficient power and stability. The optical system must be clean and properly aligned. Laser power is maintained constant via an optical feedback loop controlling the laser diode current. Therefore a weak laser may not be salvageable as the feedback loop may have done all that is feasible.

2. Photodiode sensors must be functioning correctly for data recovery and focus and tracking feedback. A 3-beam pickup has six segments: the central segments A-D are used for focus and data recovery, and the outer segments E and F are used for tracking feedback. In a single-beam pickup, segments E and F are absent.

3. Lens must be focused to within a fraction of a micrometre (µm) of optimal to produce a diffraction-limited spot. This is less than 2 µm in diameter at the disk 'pits'. The lens is actually positioned several millimetres from the disk surface and is maintained at the correct distance through optical feedback controlling the lens position using the focus coil.

4. Lens must align to within a fraction of a micrometre of the centre of the track. Tracks on a CD are spaced 1.6 µm apart. Tracking is maintained via optical feedback controlling the radial lens position using the tracking coil (or the radial positioning unit on some rotary positioners).

If the behaviour while the CD player is attempting to read the directory changes, whether a disk is in place or not, and there is no separate disk sensor, some or all of these components are functioning correctly. For example, many CD players don't attempt to rotate the spindle until proper focus has been established. Thus, if the CD rotates when in place but the bare spindle does not, it is likely that focus is being established successfully.

*Sharp CD-BA250 mini component system with 3-disk rotary changer system*

## Identifying connections to the optical pickup

In order to perform many of the tests described below, you have to locate the drive and/or signal connections to the optical pickup. While there are many variations in the construction of optical pickups even from the same manufacturer, they all need to perform the same functions. So the internal components are usually quite similar.

Fig. 41 shows the connections for a typical Sony pick-up. For laser diode as-

sembly and photodiode chip connections, a single flex cable having 10 to 12 conductors is used. The actuator connections may also be included on it or a separate 4-conductor flex cable may be used. The signals may be identified on the circuit board to which they attach, with designations as shown in the figure. The signals A, C and B, D are usually shorted together near the connector as these are always used in pairs. The laser current test-point, if present, is near the connections for the laser diode assembly.

It is usually possible to identify most of these connections with a strong light and magnifying glass by tracing back from the components on the optical block. The locations of the laser diode assembly and the photodiode array chip are usually easily identified. Some regulation and/or protection components may also be present.

There is often a pair of solder pads on two adjacent traces. Short these pads by applying a glob of solder using a grounded soldering iron. This protects the laser diode from electrostatic or other damage during handling and testing, and a multimeter can be safely used to identify component connections and polarity.

## Testing the laser diode while in the player

Without a laser power meter, it is difficult to fully verify laser functionality. However, determining that infrared is being emitted provides a reasonable assurance of laser operation.

For this test, you need an IR detector. A simple IR detector circuit is shown in Fig. 42. This unit is also useful for testing of remote controls and other IR emitters. However, you need to gain access to the lens. This may require the removal of the clamper assembly.

Once this is accomplished, prepare to position the photodiode of the IR tester within 3 mm of the lens. Plug the unit in and turn it on. On portables, you need to defeat the door interlock by using a toothpick or bit of cardboard. Some CD players have a disk-detection sensor separate from the laser assembly. This needs to be defeated for this test to work without a CD in place. If it is a simple optical sensor, a piece of black tape or paper would suffice.

Once a CD is in place and the play button is pressed, the laser must be powered. You can detect this in a darkened room because there is usually a very faint

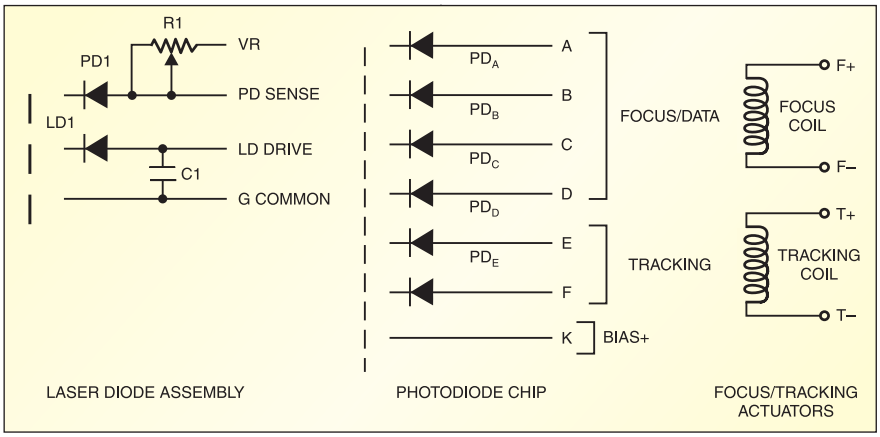


*Fig. 41: Connection diagram for a typical Sony pickup*

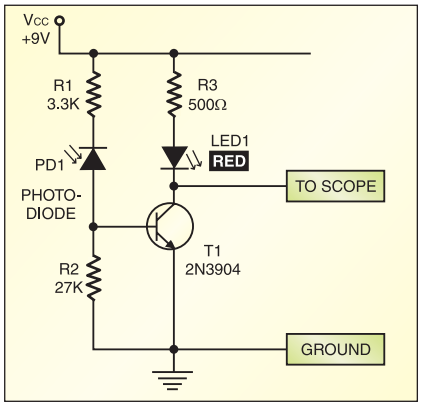


*Fig. 42: IR detector circuit*

red light emission, which you can see as a tiny red dot of light if you look at the lens from a safe distance of at least 15 cm (6 inches) at an oblique angle. Do not look into the lens directly from above or from very close as the invisible IR is much stronger than the faint red emission and potentially hazardous. If you see the faint red light, power is being applied to the laser diode.

With the laser lit, the lens should go through a few focus-search cycles (typically, two to eight). While it is doing this, position the IR detector above the lens. If the laser is working, you will get a positive indication of IR in about a 30-degree cone on either side of the lens. While you have no way of knowing whether the power output is correct, this is a reasonable indication of laser operation. Due to the wide angle of the beam, the power decreases rapidly with distance. So you need to be very close to the lens for a positive result.

If the lens moves smoothly in at least one direction (up or down), the focus actuator is functioning.

If the IR detector does not pick up a beam and you do not see the red dot, either the laser diode is dead or power is not being applied by the control circuits.

## Testing whether laser diode is being powered

If there is no indication of an IR emission but the lens is moving up and down attempting to focus, the next step is to determine whether the laser diode is being powered or is totally dead.

If you have a service manual, follow the instructions given there for checking the laser diode—usually by measuring a voltage drop across a sensing resistor or other test-point. If the reading is very low or 0, a fault is likely in the driver or the optical feedback circuitry. If the reading is very high, the laser diode is likely to be bad and the driver is unable to compensate for low or no emission.

Look for a test-point labeled 'laser power.' Even if you don't know what the reading should be, anything other than 0 would be a good indication that the driver is being enabled.

If you don't have the service manual, carefully measure across the laser diode with a multimeter to determine whether there is any voltage when it is supposed to be active. A normal reading is 2 to 3 V.

For Sony and other similar pickups, there is a chip capacitor across the laser diode. The trick is in being able to attach meter probes to these points without destroying everything!

The flex cable may also have a pair of solder pads. To attach fine wires to these for your multimeter, use a fine-point soldering iron—preferably grounded and temperature-controlled—to prevent damage.

*Warning:* For testing the laser diode, use a digital multimeter with ESD protec-

tion to avoid damage to the laser diode. Make all connections with power turned off as the momentary glitch from attaching the probes and/or an accidental short-circuit can easily burn up the laser diode and other parts.

## Testing the laser diode with an external power supply

Consider the following only if there is no indication of laser output while the laser diode is connected to the player and you do not have schematics or a service manual to determine whether the laser power circuits are functioning.

Typically, the current is in the 30-100mA range at 1.7-2.5V. However, the power curve is extremely non-linear. There is a threshold below which there is no output. For a diode rated at a threshold of 30 mA, the maximum operating current may be as low as 40 mA. A sensing photodiode is built into the same case as the laser diode to regulate beam power. It is critical to the life of the laser diode that under no circumstances is the safe current exceeded even for a microsecond.

Laser diodes are also extremely sensitive to electrostatic discharge, so take appropriate precautions. Also, don't try to test them with a volt-ohm-meter, which could exceed their safe current rating on the low-ohms scale. Even connecting the test leads can blow the laser diode from static. Always make or break power or test connections with the player turned off.

Use a 0-5V DC linear supply with a 50-ohm resistor in series with the diode; a switching supply's spikes may destroy the laser diode. If you use a variable resistor, make sure it is at its maximum resistance when you start, so as to keep the current under 20 mA. Keep in mind that a wall wart (a small power-supply brick with integral male plug, designed to plug directly into a wall outlet) rated at 5V may actually put out 8V or more when unloaded, so check the current into a short circuit before connecting the laser diode.

Slowly increase the current until you get a beam. Use an IR detector for beam detection. If you get the polarity backwards or are actually measuring across the internal photodiode, the voltage across the diode goes above 3 volts or is less than 1V. Then, turn power off and reverse the leads. Some laser diodes get destroyed by a reverse voltage greater than 3V—the reverse voltage rating is listed in the specification sheet.

Without a laser power meter, however, you have no way of knowing when the limit for safe beam power (for the laser diode) is reached. For this test, increase the current only until you get an indication on the IR detector or you see the red dot. You are not trying to measure power, just to see whether it works at all. A typical threshold is around 30 mA. Sometimes, the operating current is marked on the pickup. Do not exceed this current.

If you detect a beam and there was none before, the problem is most likely in the player's control or power circuits, not in the pick-up.

## Laser power adjustment

As mentioned earlier, the laser diode may get destroyed when attempting to adjust its output power. However, if you suspect a weak laser as indicated by noisy playback or poor tracking performance, and have eliminated all other possibilities such as servo adjustments, attempt one of the procedures described here.

What adjusting the laser power probably does isn't compensating for a decrease in laser diode intensity, but rather a buildup of dust and other junk on the optics (possibly internal and inaccessible), which reduces the beam intensity at the CD and the return beam intensity even more. There is a subtle difference as the optical output of the laser diode itself is feedback-controlled and shouldn't drift much and the result of an adjustment will be an increase in the laser output power beyond its normal range—which may shorten its life substantially.

If the laser output power has decreased, there is probably nothing that can be done as the feedback circuit is already doing its bit and the adjustment will have little effect. Thus, make sure the optics are as clean as possible before you touch the laser power.

The following will enable you to play a disk, even if it has some problems with noise or tracking: Put the oscilloscope probe on the RF test point. While the disk is playing, you should see the eye pattern. Mark the exact amplitude of the peaks. Also note the playback quality, so you can recognise if it changes.

While the correct voltage for the eye pattern is not the same in all players, typical values are in the 1-2V range. If you find it to be only a few hundred mV, there is likely to be a problem. *Caution*: A weak eye pattern can also be due to improper focus bias adjustment. Check whether it is an electronic problem. The laser power may be normal.

*Philips ultra-slim DVD-video karaoke player*

Turn the laser power adjustment with the player power switched-off to avoid the possibility of electrical noise causing current spikes. Mark the exact position of the laser power adjustment, so you can get back to it if there is no effect or it makes things worse.

Turn the control the slightest bit clockwise. Turn on the power and/or note the eye pattern amplitude. If the laser diode is not at the limit of its power, you should see the amplitude change from what it was. If it has decreased, try the other direction.

Note the playback quality. Has it changed for the better? If not, laser power is probably not the problem. If the amplitude of the eye pattern is unchanged, either you are turning the wrong control or the laser is at its power limit—and it may get damaged soon. Try the same test in the counterclockwise direction if the am-

plitude decreases.

If there is improvement, you can risk leaving the control at the new higher-power setting, realising that you may be shortening the life of the laser diode. Do not push your luck by continuing to turn up the power, unless you have tried all other alternatives.

If you do not have an oscilloscope, you can still try the above procedure by carefully listening to the audio to determine whether there is any change. It's a little bit riskier: The laser power adjustment may be very sensitive and you have no direct way of knowing how much you have increased the setting.

## Testing the focus and tracking actuators

If your CD player has a rotary positioner, there may be no separate tracking coil as coarse and fine tracking may be combined.

Typical linkages between the lens/coil assembly and the body of the pickup are a sliding shaft (focus) and rotation on the shaft (tracking), or a hinged hinge. With a sliding shaft and rotation on the shaft, the slide can get gummed up, preventing reliable focus and tracking. With a hinged hinge, one or both hinges may break, as these are often made of thin, flexible plastic. Repair is not really possible.

To test whether the lens is focusing or tracking properly, perform the following: First, identify the cable leading to the focus and tracking voice-coil mechanism. This is usually a 4-conductor cable separate from the data and laser cable (at least at the pickup end). Disconnect it from the main board before testing. Using a digital multimeter, you can locate the pair of coils with very low resistance (a few ohms). One of these is focus coil and the other is tracking coil.

Construct one of the following test circuits:

1. Take a 4-5V DC eliminator. Connect a variac at its output and a 22-ohm, 1W resistor in series with a pair of 50cm, 24SWG insulated wires.

2. Take a 5V DC power supply connected in series with a 100-ohm variable resistor and 22-ohm, 1W fixed resistor with a pair of 50cm, 24SWG insulated wires.

Gain access to the lens for visual inspection. For this, you need to eject the disk, open the drawer or, in some cases, actually remove the clamper. In a portable or boombox, the lens is readily accessible. Unplug the CD player from the AC socket or remove the batteries, as you don't need to use its internal power.

With power supply switched off or the variac turned all the way down, connect the 24SWG leads to one of the located pairs of coils. Now, turn on the power and slowly adjust the variac or rheostat while watching the lens. If you are connected to the focus coil, you'll see the lens moving up and down. If you are connected to tracking coil, you'll see it moving from side to side.

If there is no motion, turn off the power supply, reverse the polarity and try again. For a typical pick-up, the 4-5V power supply and a minimum of 22-ohm resistor should cause the lens to move through the entire range of motion up and down or side to side, as appropriate. Once you have exercised the first coil, switch connections and repeat for the other. If the motion is jerky, the lens assembly is dirty.

Clean the lens assembly carefully first with a bit of compressed air (not high-pressure) and then with Q-tips and isopropyl alcohol. Do not lubricate. Repeat the tests after cleaning.

If both the tests are positive, the focus and tracking actuators are functioning. If either you were unable to locate both pairs of coils or one or both actuators did not move, you have located a problem. An open coil can be due to a cable problem or a break in the coil. If the break is right at the solder connections, which are usually visible once the plastic protective shroud is popped off, you can repair it. However, this requires a great deal of manual dexterity and patience, as the wire is really fine.

Shorted turns in the fine coils or an intermittent are still possible. Shorted turns reduce the frequency response of the servo, reduce the reliability of focus or tracking and increase the needed servo driver power. A CD player that is overly sensitive to slight disk defects even after all the proper adjustments have been performed may conceivably be a result of this type of fault. An additional symptom may be an unusually hot servo driver IC. However, many of these ICs run hot normally, so don't worry unduly as the possibility of shorted turns is really quite remote.

An intermittent may only show up during dynamic operation, with certain CDs or other peculiar circumstances. The intermittent could be at the solder connections or the fine, printed ribbon cable that connects the moving lens assembly to the remainder of the pickup.

## Testing the photodiode array

The photodiode array in an optical pickup consists of an IC with typically four or six detector segments. Four segments are used in the less common single-beam pickups, while six segments are used in 3-beam pickups.

*Panasonic SC-AK410S Nitrix series mini system with 5-CD changer and 3-way speakers*

These segments are usually designated A through F. A, B, C and D form the main detector, which is used for both focusing and data recovery. Generally, segments E and F are used in a 3-beam pickup for fine tracking feedback. The same has been assumed in the following discussion.

All the six photodiodes are connected to a common point, which, during operation, has a DC bias voltage of around 5V. If the photodiodes are connected in common-anode configuration, it will be negative. If common-cathode configuration is used, it will be positive. The reason is that the photodiodes need to be reverse biased for normal operation. The outputs

of the photodiodes feed several operational amplifiers, which are set up to amplify the current from the photodiodes. The normal connections may be at virtual ground potential or these may feed into large-value resistors.

The connector to the photodiode array is usually separate and typically has at least eight wires—comprising connections to photodiodes A through F, ground and bias voltage.

You need to identify the wires. First, locate the ground using the ohmmeter. Then locate the bias—it usually goes to a low-value resistor and then to the supply. Another way to identify the bias wire is to turn on the player and measure each of the possibilities: The bias is the highest or the lowest, with no noise or ripple. It is powered all the time.

Now identify the photodiode segments. Very often the connections are marked on the circuit board; for example, there may be several labeled test-points designated A+C, B+D, E and F. Since the A and C segments and B and D segments are usually shorted together on the circuit board, this provides all the information needed to identify the photodiode connections. It is not important to distinguish between A and C, or B and D for the following tests, though you will want to be able to separate them.

With power off, there is essentially no light on the photodiode array. Unplug the photodiode connector from the main board. Using your ohmmeter, test each diode for open and short, as you would test any signal diode. There should be a junction drop in the forward direction and very high resistance in the reverse direction. If you use a digital multimeter in diode testing mode, the junction drop is typically 0.7 V. There may be a very slight difference between the readings for segments A to D and those for E and F.

An initial test of photodiode response can be made by using an external light source (a flashlight or other incandescent bulb or IR remote control) to illuminate the lens directly from above. With the multimeter connected to reverse-bias each diode segment, illuminate the lens. The resistance reading should drop, possibly dramatically. Segments A to D should show reasonably similar sensitivities but these may differ for segments E and F (which should be similar to each other).

Similarly, with the photodiode connections restored to normal, you can use an oscilloscope to monitor the RF test point. A source of IR directed towards the lens from above may result in a detectable change in the signal, but only when the photodiode array is properly biased. This signal may be present all the time the CD player is turned on or only when the player is trying to focus or perform some other operation. With an IR remote, you should actually see the pulsed signal for each key-code. On a typical Sony CD player, you could get about 0.1V signal at the RF test point using a VCR remote control as an IR source.

However, even on a functional pick-up, due to the nature of the optics, these responses may be very weak or undetectable. Thus, failure of either of the above tests is not a strong evidence of a bad photodiode array.

Any unusual reading such as a significantly lower resistance for one of the diodes, a short or open diode, a short between diodes or variations in sensitivities is an indication of a problem. This is somewhat unlikely, though bad solder connections or breaks in the flexible cables are not ruled out.

A defect found in the photodiode array usually means that the laser pickup is not salvageable with reasonable effort. Even if you could locate a replacement photodiode array, aligning and soldering the surface mount package is quite a challenge without the factory jigs.

Assuming that these tests don't turn up anything, the next step is to verify that the photodiodes are picking up an optical signal and evaluate the relative strengths of each segment using the laser diode, optical system and disk combination. For these tests to confirm proper operation, the optical alignment must also be correct.

*Sony DVP-NS700P DVD player*

For the tests using the internal laser diode, you need to set up either an adjustable focus with continuously rotating spindle or a stationary spindle but sweeping focus. The latter is more straightforward but requires the optional signal generator for best results. In each case, the objective is to cause the lens-disk distance to sweep through perfect focus without requiring the focus servo loop to be closed. This results in a signal that includes the point of maximum signal amplitude on a periodic basis. Alternative methods may be used to accomplish the same purpose. Both techniques require the use of an ad-

justable power supply.

The test set-ups are described below:

***1. Adjustable focus with continuously rotating spindle.*** For the spindle motor, you need a 1.5V battery or power supply with a suitable series resistor to cause the spindle to turn at approximately 1-2 Hz (revolutions per second). (*Warning:* Disconnect the motor from the main board.) The unavoidable wobble of any disk is essential in this case and sweeps the focus distance by more than enough to cover the entire focus range of interest.

It has been assumed that the spindle is driven by a conventional permanent-magnet DC motor. If it is a brushless DC motor, some of the control electronics may be external to the motor and you will not be able to provide a DC voltage to get it rotate. If this is the case, you must use a stationary spindle but sweeping focus.

***2. Stationary spindle but sweeping focus.*** This is a better method but requires a signal generator for the easiest use. You can do this by hand using a variac or rheostat. A better method is to use a 1-10Hz sinusoidal or triangular wave from a low-frequency signal generator with a low-impedance output or feeding an emitter follower or audio amplifier to boost the current. This signal is then fed into the coil along with the focus offset derived from the power supply.

It is possible to dispense with these test set-ups and just use the normal focus search of the CD player itself to provide the sweep. However, since you will be interfering with the proper feedback by removing selected sensors, there is no assurance as to what the microcontroller does. Therefore breaking the feedback loop, as we are doing, is preferred. However, if the CD player appears to make many attempt at focus, this may be worth a trial.

You may also need a new disk—preferably one you do not care much about—as it may get scratched due to opening the drawer accidentally or doing something equally undesirable while the disk is still rotating.

Locate a 1-mega-ohm resistor and securely fasten it to a ground near the photodiode connector. Put the scope probe on the other end with its ground clipped to the same ground point as the resistor. Bend the free lead of the resistor completely over so that it is able to hold the end of a wire like a mini-clip lead.

Mark down exactly how the connector is wired so that as you remove individual wires, you are able to get them back in the proper spot. Presumably, you have already made a diagram of the photodiode connector wiring. Component players often have connectors with individually removable socket pins. A fine jeweller's screwdriver or paper clip may prove handy in removing these one at a time.

*Fisher Electronics' Slim-1400 digital AM/FM/CD-R/RW executive slim audio system*

Turn on the power supply and adjust the focus to about mid-range. Start the spindle rotating or turn on the signal generator to provide a small sweep—about 1/10 Vp-p, as measured on the coil.

## Making the photodiode measurements

Remove the wire corresponding to the photodiode to be tested (say, A) from the connector but leave the connector itself plugged into the main board. Set the scope for 1V/div. vertical deflection in slow, free-running sweep mode.

Clip the A wire into the resistor. Now, turn on power to the CD player. While the player attempts to focus, slowly adjust the focus voltage while observing the scope. As you approach proper focus, you will see the signal increase greatly (depending on the polarity), pass through a maximum and then decrease. Depending on the design of the CD player, you may need to turn it off and on several times before you locate the signal, since the microcontroller may give up pretty quickly with no focus or tracking coil servos (as you've disconnected the actuators). The service manual may guide you on how to force the laser to be powered all the time. Leave the focus set near the middle of the region of high signal.

If you use the signal generator to perform the focus sweep, you need to optimise the amplitude of the signal by adjusting the signal generator output and offset from your power supply.

You may not need to touch the settings for testing the remaining photodiode segments.

Repeat the testing procedure for each of the photodiodes A through F. All should produce fairly similar signals, say, within 20 per cent of one another in amplitude. If A, B, C and D, or E and F, differ from one another by more than, say, 20 per cent, there is a serious optical alignment problem in the pick-up. Else, the photodiode array may be bad. Partially shorted photodiode segments are also possible. In this case, the outputs will not be independent. Loading one segment's output with a resistor may affect the output of other segments.

Such a discrepancy in photodiodes A to D prevents the establishment of a proper, stable lens position at the optimal focal distance. This prevents the formation of a proper eye pattern and subsequent data recovery. A significant difference between E and F (beyond the adjustment range of the tracking or E-F balance control) prevents proper tracking. However, the signal amplitudes from photodiodes A through D and E and F may differ as photodiodes A through D operate off the main beam and E and F operate off the first-order diffracted beams (which are weaker). As with the basic photodiode tests above, a failure here usually requires replacement of the entire optical assembly.

As noted, if the pick-up's optical alignment is way off, there could be significant differences in photodiode responses. On component-type units, it is unlikely that the optical alignment shifts on its own. Portables dropped down accidently or automotive units subject to constant bumps and vibration could have alignment problems, however. If this eventually results in improved uniformity of the photodiode response, alignment could be the problem. If you can, more or less equalise the response, reconnect the servos and attempt to get an eye pattern. If you can optimise the eye pattern stability and amplitude using the optical alignment adjustments and servo adjustments, you would have achieved proper alignment.

*To be continued...*